Manual of Instructions

RFL

UNIVERSAL
Gaussmeter

Radio Frequency Labs., INC.
TEST & SERVICE PRODUCTS DIVISION
Boonton, New Jersey, U.S.A.

Model 1965

Designers and Manufacturers of Electronic Equipment since 1922

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THIS BOOK TO BE USED WITH EQUIPMENT

SERIAL NO. _____

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Model 1965

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Radio Frequency Labs., INC.
Boonton, New Jersey, U.S.A. 07005

Book No. MA-20980

Telephone: 201-334-3100 TWX: 510-235-8322 Cable: RADAIRCO, NJ

Figure 1. Front View of Model 1965 Universal Gaussmeter.

General Description

PURPOSE

Model 1965 Universal Gaussmeter is capable of three distinct modes of operation. The unit will measure absolute magnetic field densities, make differential or gradient flux measurements and detect incremental variations of a field, thus resulting in a gaussmeter having maximum versatility.

The unit is completely transistorized, providing high stability and virtually no warm-up time. Operation can be either from 115/230-volt AC power line or standard type D flashlight cells, determined by interchangeable plug-in modules. The indicating meter is a large, easy-to-read TBS instrument. The six inch scale has parallax compensation which makes precise readings a relatively easy accomplishment. Thirty-three overlapping ranges can be selected from 0.1 gauss full-scale to 20,000 gausses full-scale. Scale factors are arranged on a 1 - 2 - 5 basis, providing a maximum of resolution with a minimum of reading error.

Absolute flux density measurements are performed using one Hall probe. The same single probe is used for expanded scale operation. The expanded scale feature allows investigation of incremental field variations in the presence of a large magnetic field. For example, determinations of flux variations as small as .001 gauss may be observed in a field of 100 gausses.

The differential operation requires the use of two matched probes. Simultaneous difference readings can be taken in a given field, or two fields may have their differences measured at the same instant. This feature is especially valuable where the field(s) are varying in amplitude and instantaneous comparisons are required. Receptacles and selector switches are included on the back of the Model 1965 for using external accessories for read-out, such as an oscilloscope, recorder or digital voltmeter. A zero gauss chamber consisting of concentric mu-metal shields is built into the front panel of the Model 1965. This feature facilitates electrical balance of the Hall probes(s) in a near zero field level.

By using either of the two probes supplied, the Model 1965 will measure magnetic field densities to a high degree of accuracy. It is a complete instrument in every respect for making direct measurements of flux density and for analyzing location, variations, homogeneity and intensity of stray magnetic fields. Some specific engineering and production uses include measurement of magnetic fields around cables, motor field intensities, relay design effectiveness and minimum leakage paths, transistor and printed circuit fields, minimum fields around shielded magnetrons, ship and aircraft compasses, ferrite isolation fields, shaker table stray fields, effectiveness of shielded rooms, meter magnets, fields around phono pickups, and high impedance input transformers and pre-amps.

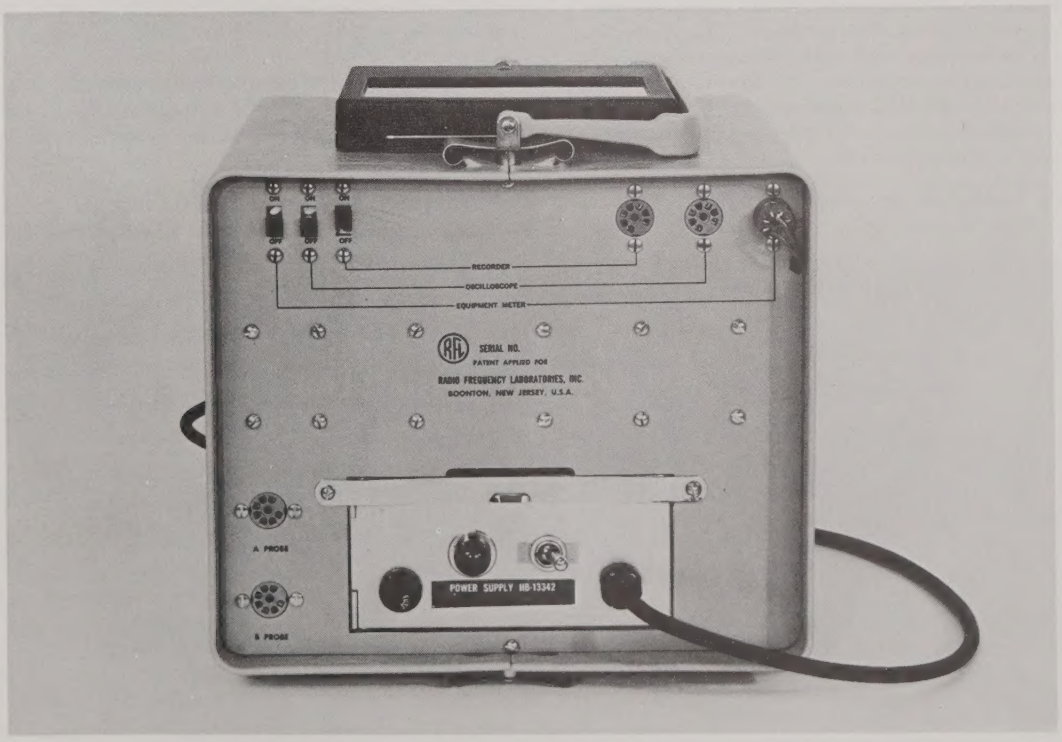


Figure 2. Rear View of Model 1965 with HB-13342 AC Power Supply.

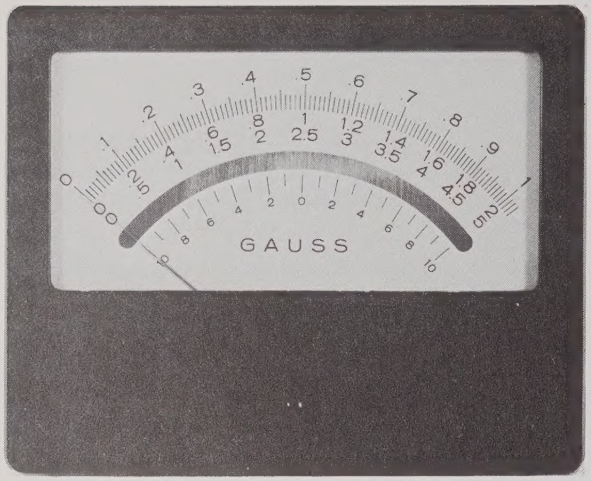


Figure 3. 1/2-Size Reproduction of TBS Meter used in Model 1965 Universal Gaussmeter.

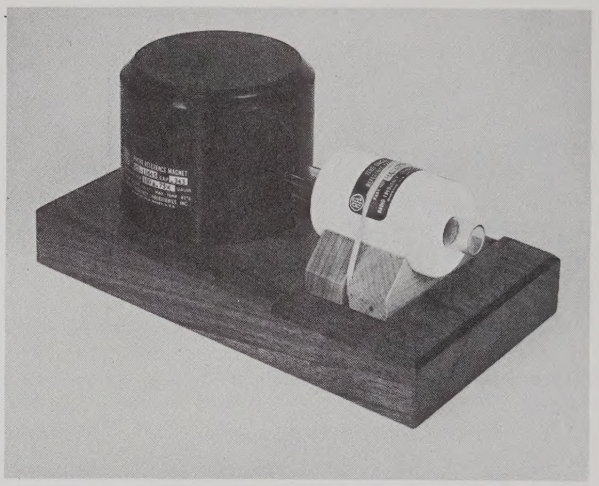


Figure 5.
HA-16440 Stand Assembly.

PHYSICAL FEATURES

The aluminum cabinet is covered with gray vinyl which resists scratches, dents and is easily cleaned. Overall size is 10" x 9" x 9"; total equipment weight is about 17 lbs. with either power supply

All operating controls are mounted on the front panel, except for the AC Supply ON-OFF switch which is mounted on the supply. See Figure 2.

The meter used in the Model 1965 is a Weston precision, taut-band suspension instrument providing the maximum in reliability, resolution and ruggedness. The scale in Figure 3 has a six inch overall length; divisions are spread out to enable excellent resolution. The pointer is painted day-glow red while the scale pickets are black. This feature provides sharp contrast and enables accurate readings to be made easily and rapidly.

The meter mechanism provides better than 0.5% repeatability, while its long scale with the parallax compensating mirror and linear divisions enables resolution to within 1/4 of a scale division.

Since it employs a shielded, core magnet mechanism, it will produce practically no stray field to affect nearby magnetic measurements.

A zero-center scale is provided for use in the expanded scale mode, although zero left operation can also be used if desired. This enables changes of polarity to be determined while probing minute field variations. The 1 - 2 - 5 scale factor provides a generous overlapping of ranges and enables reading to be made from .04 gauss to 20,000 gauss using only the top 3/5 of the meter scale.

This precision indicating meter is calibrated in gauss and may be raised to 45° and 60° positions for most convenient reading. It can also be removed from the cabinet and placed in the work area.

The electrical circuits are divided into major functions and are packaged in modular cases which provide effective

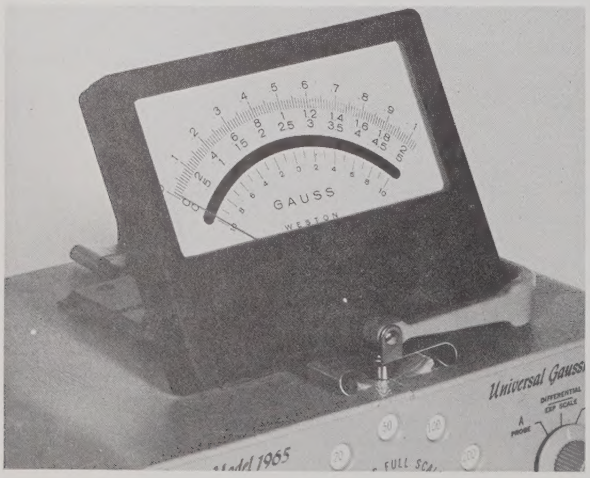


Figure 4. Indicating Meter has 3-position tilt adjustment for easy and convenient reading.

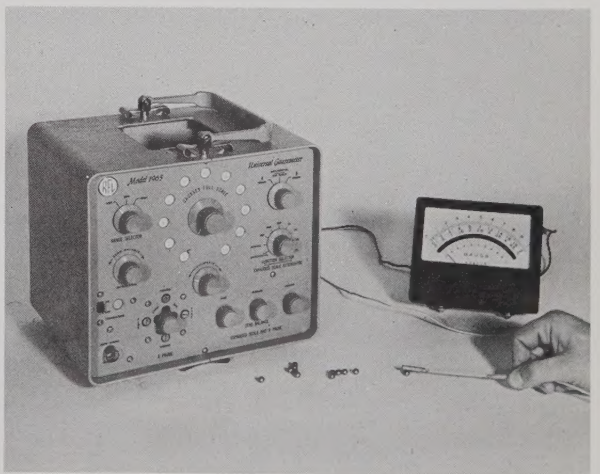


Figure 6. Indicating Meter has Flexible leads; can be easily placed in Work area.

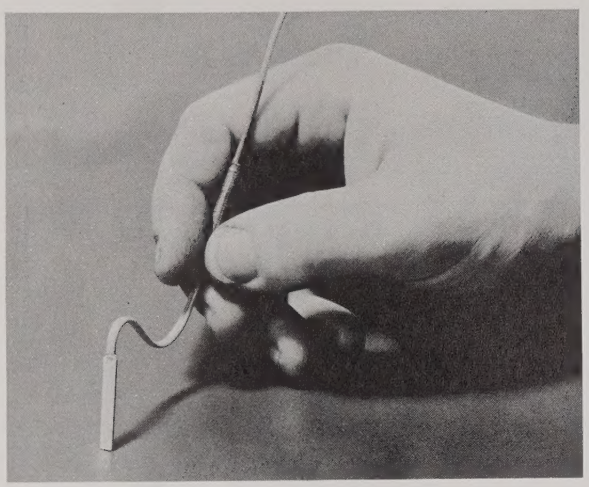


Figure 7.
Showing Flexibility of Probe Cable.

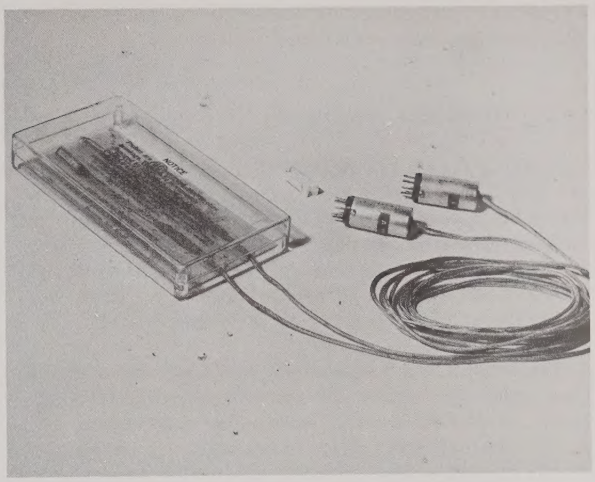


Figure 9.
Keep Probes in Box When Not Being Used.

electrostatic and magnetic shielding. Service or parts replacement is relatively simple. Access to these assemblies is quickly accomplished by removing either, or both, halves of the cabinet; these are held in place by two spring tension retainers.

A shielded, Mu-metal zero gauss chamber is mounted back of the front panel with access through a hole in the panel. An additional 0-gauss chamber is available together with a transparent plastic guide tube which is inserted in both the zero gauss chamber and the 100-gauss reference magnet HB-11645. When mounted on the wood stand, as shown in Figure 5, this assembly provides a convenient and accurate setup for zero balancing and calibrating both probes while held in the spacer block. The flattened end of the tube, which is inserted in the reference magnet, holds the spacer block so that both probes are exactly normal to the field of the magnet.

PROBES

Two matched, indium arsenide Hall effect probes are available for measuring fields perpendicular to their flat tip blade. The InAs elements are .050 wide x 0.1 long and are contained in a glass reinforced epoxy shell which is 1mm (.039") thick x 13/64" wide x 1" long. The connecting cable is light and flexible for probing narrow apertures and confined spaces as shown in Figure 7. The probe tip should never be bent or squeezed, since the InAs element is crystalline and fractures easily. During shipment and when not being used for extended periods, the probes are protected by storing in the plastic box supplied. Otherwise, protect them as shown in Figure 9; be sure both cables are in the two slots in the bottom half of the box.

The spacer block, used to hold both probes parallel for differential measurements, also offers additional protection. See Figure 8. This block provides four different parallel spaces and a vertical arrangement with the axes in alignment.

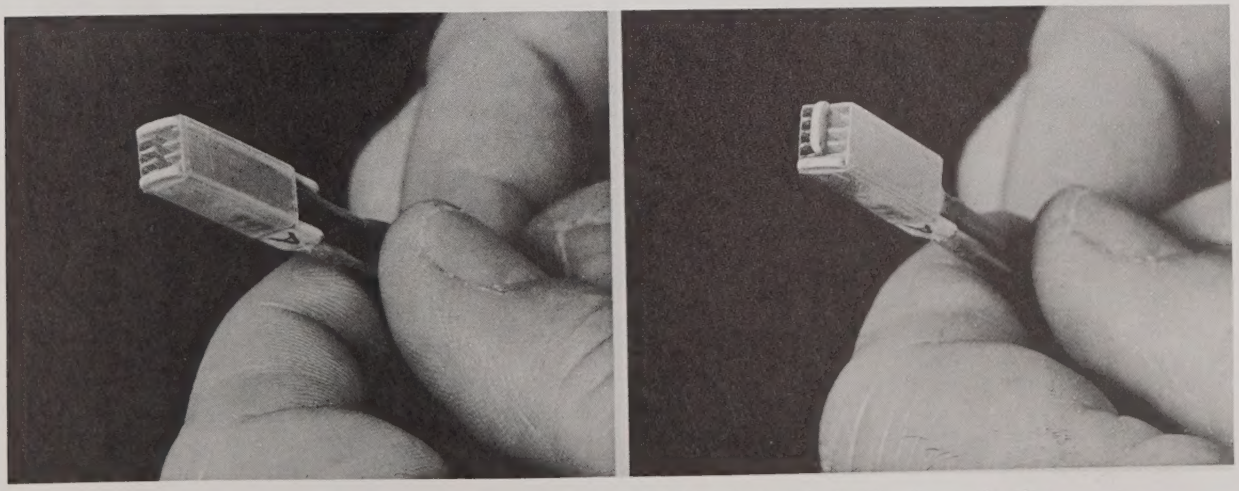


Figure 8. Parallel Spacings of .050, 0.10, 0.150 and 0.20 Inch, Plus Perpendicular Position, are Provided by Split Spacer.

Flat and axial probes are available for absolute and incremental or differential use.

PROBE REFERENCE MAGNETS

A 100-gauss HB-11645 Probe Reference Magnet accurate to ±1% and having a .343 inch gap large enough to accept the spacer block holding both probes is supplied. For single probe calibration, accurately calibrated permanent reference magnets having values from 5 to 20,000 gausses may also be ordered. Accuracy varies from ±0.75% to ±1.5% depending on the value.

These reference magnets are stabilized and adjusted using mutual inductors and search coils with National Bureau of Standards certificates. The magnets are coaxial to eliminate stray fields in the area of measurement and to protect against possible magnetic change in the reference when contacting other strong magnets. The pole faces are accurately machined of special alloys to provide uniform flux distribution.

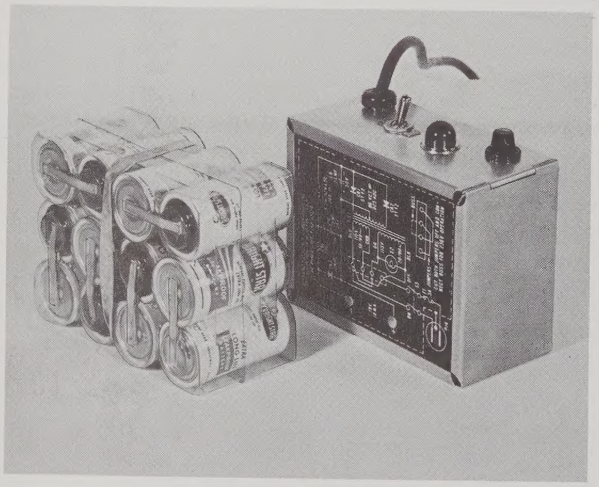


Figure 10.
HB-13375 Battery Supply and HB-13342 AC Supply.

POWER SUPPLIES

The Model 1965 can be ordered for use on a 115 or 230-volt, 50/60 cps line or for battery operation.

The AC Power Supply HB-13342 supplies an 18-volt DC output at 30MA and can be internally connected for 115-volt or 230-volt operation. It is equipped with an approved, 3-conductor power cable and plug with grounding pin.

The HB-13375 Battery Supply is equipped with 12 standard D-size, 1.5-volt flashlight cells which provide about 75 hours of intermittent 4-hour per day operation.

Both power supplies are identical in size and plug into the back of the Model 1965. They can be removed or interchanged quickly without tools. For normal laboratory or field use, battery operation is most convenient. For continuous service or daily production use, the AC Supply is recommended.

Table I.

Limits of Error
in the Calibration of a ±1.0% Reference Magnet

Error	Description
±0.25%	Bureau of Standards accuracy of calibration of search coil.
±0.05%	Bureau of Standards accuracy of measurement of mutual inductor.
±0.10%	RFL accuracy of measurement of DC current.
±0.45%	RFL fluxmeter transfer reading error.
±0.15%	Non-uniformity of field in gap.
±1.00%	Total error

ELECTRICAL FEATURES

Basically, the Model 1965 consists of two probes, a 3000-cycle oscillator, two constant current amplifiers, two matching filters, an adder circuit, a precision attenuator, an amplifier, a linear rectifier, a meter and a power supply (AC or battery). The use of transistors throughout provides maximum temperature stability, reduces warm-up time and permits economical battery operation for field use in addition to AC line operation.

For research work and special applications, the oscillator output transformer and the amplifier input filter are provided with a series of push-pin taps for probe impedance matching from 2 to 50 ohms. Using these facilities, a variety of Hall effect materials can be measured or employed for magnetic field studies. Various single element Hall effect probes are available from different manufacturers and can be cabled to the standard male plug supplied with the Model 1965. Unless a response curve or similar data are supplied, each probe should be measured in a set of reference magnets to determine its linearity of response over the various ranges to be used to determine its over-all accuracy.

The amplifier is linear and powerful enough to drive an external recorder. There are three output receptacles on the back panel (see Figure 2) for an external recorder, oscilloscope and meter. These outputs can be switched, as desired, into the equipment circuits, one at a time, by three slide switches. An accessory connecting cable with plug is stored under the meter.

Technical Data Summary

MODEL 1965 UNIVERSAL GAUSSMETER

EQUIPMENT PHYSICAL DIMENSIONS:

10" x 9" x 9". Weight is about 17 pounds.

RANGES:

0 to 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000 and 10,000 gausses direct reading. To 20,000 gausses using correction data supplied with probe. To 28,000 gausses using 10,000-gauss reference magnet and data available at additional cost (Option B).

ACCURACY:

Absolute and differential modes of operation. ±(1% + reference magnet accuracy) when using probe reference data supplied. Within ±3% direct reading of full scale range values to 10,000 gausses. Within ±3% to 20,000 gausses using probe calibration data supplied.

Expanded scale. Absolute accuracy same as stated above. However, ±3% of the expanded scale range used also applies. For example, absolute field level 4500-gauss using 5000-gauss range. Expanded scale range = 5-gauss range. Accuracy = ±3% of 5000-gauss + 3% of 5-gauss = 150 + .15 gauss = 150.15 gauss.

MAGNETIC FIELD FREQUENCY:

Permanent magnetic and electromagnetic fields and AC fields from 20 Hz to 400 Hz. On AC fields, gaussmeter reads average value. Correction data for fields above 60 Hz are supplied.

TEMPERATURE STABILITY:

Less than 1% change of sensitivity and less than one gauss zero balance shift for 10°C change of element temperature. Over temperature range of -40°C to +60°C the InAs element probe output will vary less than ±4%.

ACCESSORY OUTPUTS:

Accessory output receptacles are located on rear of cabinet.

Oscilloscope: 2 volts maximum. Display includes 3000 Hz carrier frequency unless external filter is used.

Recorder: 1 mA DC into 1500 ohms. A digital voltmeter may also be used on the recorder output connection.

REFERENCE MAGNETS:

A wide variety of reference magnets is available. For maximum versatility the Type HB-11645 magnet (100 gauss ±1% with .343" gap) is recommended. This calibration standard will permit operation of the Model 1965 in all three modes of operation and over all ranges.

The Type HB-11279 (500 gausses ±1.5%) magnet is used for all axial probes.

The Type HB-9272 (1000 gausses ±0.75% with .062" gap) magnet can be used for absolute measurements with a single flat probe over the ranges from 1 gauss to 20K gausses FS, providing slightly higher accuracy and at less cost.

SUPPLY:

Type HB-13342 AC Supply, 115/230 volts 50/60 Hz. Type HB-13375 Battery Supply complete with 12 D-size, 1.5 volt flashlight cells. (Approx. 75 hours operational life).

PROBES:

Various flat or axial probes are available. Single probes are used for absolute and expanded scale measurement. Two matched probes are used for differential operation. They can be either flat or axial probes.

Theory of Operation

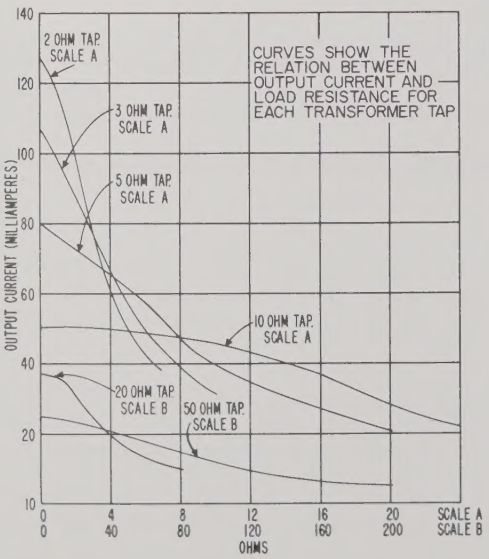
THE HALL EFFECT

When electrons move in a conductor perpendicular to a magnetic field, they are deflected toward one side of the conductor (left or right depending on the direction of the magnetic field) in a direction normal to the direction of both the initial electron flow and the magnetic field. The force deflecting the electrons is directly proportional to the electron velocity (current) and the magnetic field intensity. This deflection process continues until sufficient charge has accumulated at the sides of the conductor to establish a transverse electric field which opposes further deflection of charge carriers. The transverse potential difference thus created is called the Hall voltage and the phenomena causing it, the Hall effect. The magnitude of this potential in volts is given by the equation:

$$E = \frac{RIH}{t},$$

where I is the current in amperes, H is the magnetic field strength in gauss, t is the thickness of the sample in centimeters, and R is the Hall coefficient in volt-cm/ampere gauss.

Under the conditions shown in Figure 11, the terminal B will be negative with respect to terminal A for metals and semiconductors in which the current is carried by electrons. Reversing the field reverses the output polarity. As shown by the equation above, the width of the strip is not a factor of the output as long as it is large compared to the thickness. The strip should be twice as long as it is wide or the output drops off. For thin strips the output is unaffected by the frequency of the field in the audio range. The Hall voltage is maximum when the plane of the element is perpendicular to the magnetic field.



3000 c/s Oscillator Output

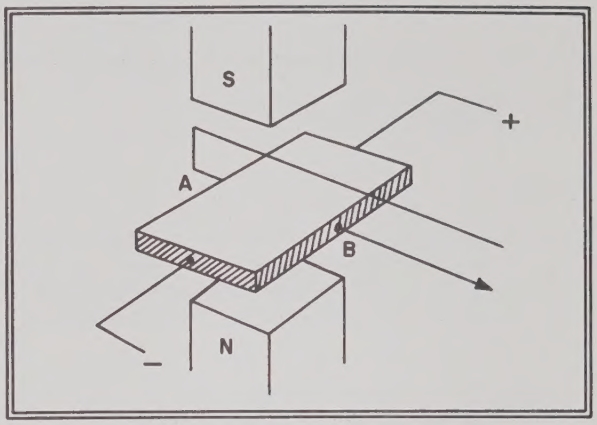


Figure 11. Schematic Circuit Arrangement for the Measurement of the Hall Coefficient.

Practical materials for Hall elements are films and slabs of specially refined semiconductors. The sensitivity, temperature stability and linearity to fields can be varied through wide ranges by selection of materials. One characteristic can usually be improved at the expense of the other characteristics. Hall elements made of InAs, InSb and other similar III-V compounds required a loading resistor across the Hall contacts for best linearity in strong fields above 2000 gausses. This resistor is determined experimentally for each element.

Flat and axial probes for the Model 1965 Gaussmeter are manufactured using a very thin piece of InAs which is selected for use in the temperature range of 0°C to 74°C.

RECEIVER SENSITIVITY

The 3000 c/s input voltage to the filter of the receiver necessary to move the meter to full scale on the 1000-gauss range for each filter tap is given below. These data will be found useful if Hall elements other than those supplied for the instrument are used. The input voltage for any other range is obtained by multiplying the voltage at 1.0 kilogauss by the other full-scale range expressed in kilogauss.

Filter Tap (ohms)	2	3	5	10	20	50
Input Voltage (mV at 1 kilogauss)	2.5	2.75	3	3.8	5	7.6

PROBE SENSITIVITY

The Hall elements normally used with the Model 1965, as matched to an output load for best linearity, will supply 2.5 mV output when subjected to a 1000-gauss field and driven with 50 mA±20%. The average value of K is 50×10^{-6} in the formula: $V_H = KHI$, where V is the Hall voltage in volts, H is the magnetic field in gauss and I is the current in amperes.

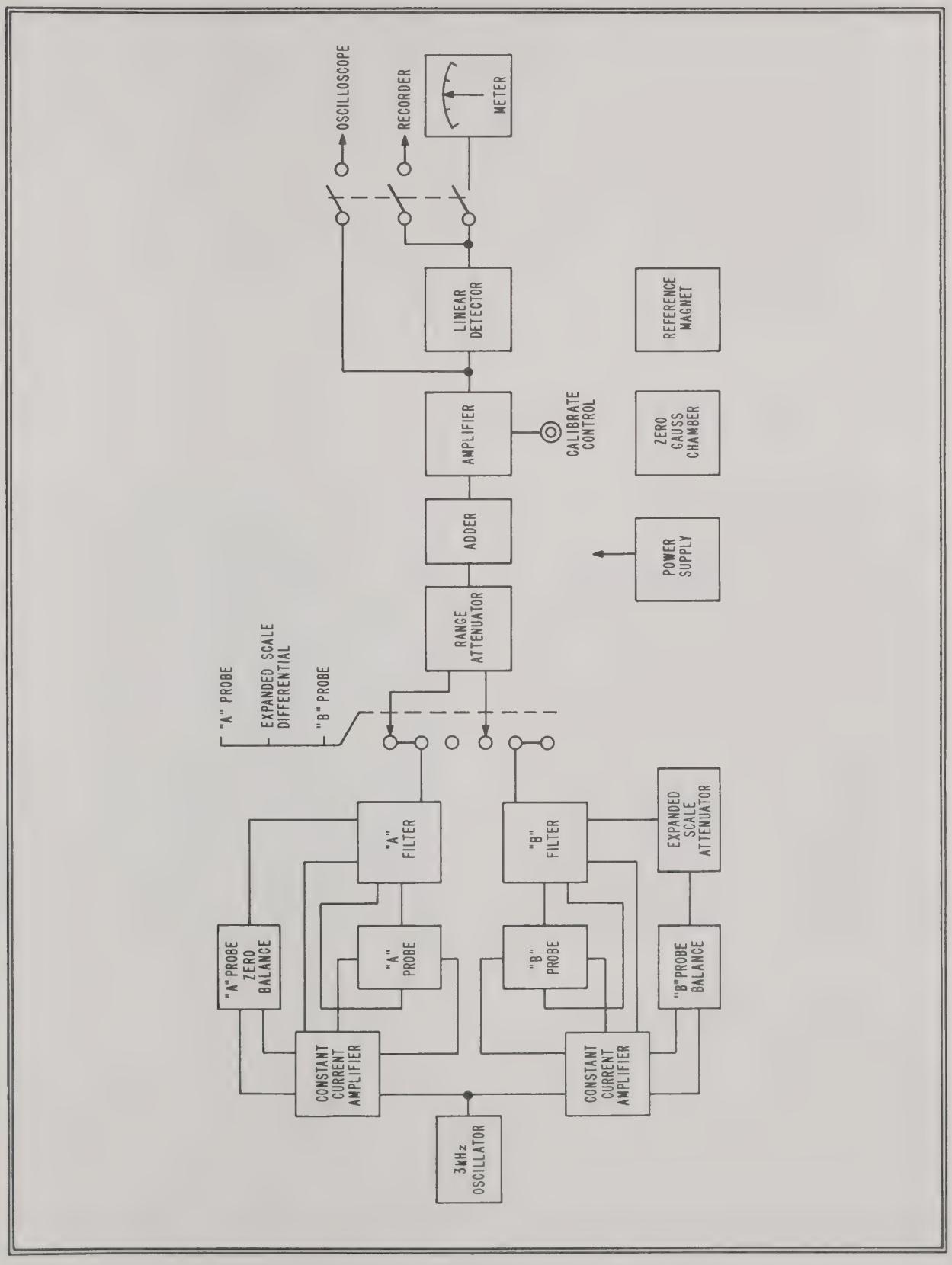


Figure 12. Block Diagram of Model 1965 Universal Gaussmeter.

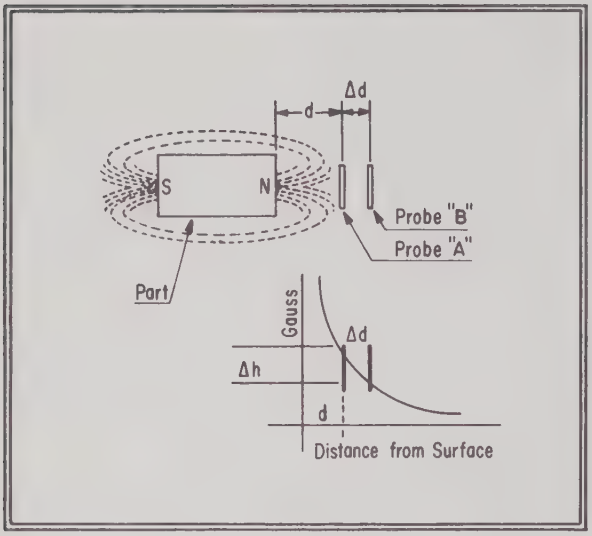


Figure 13.
Measurement of Field Gradient.

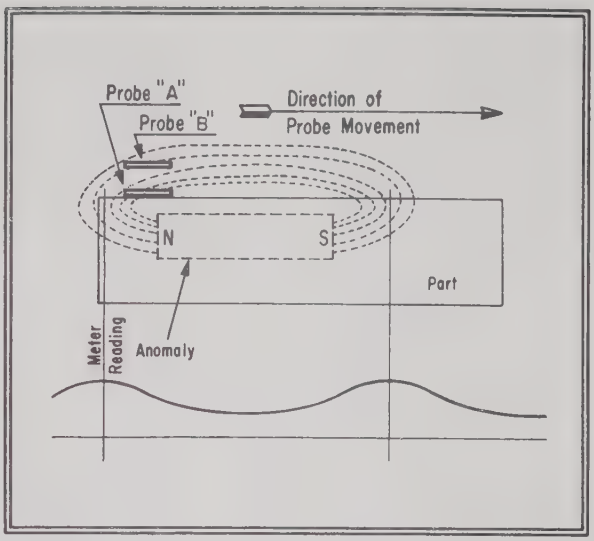


Figure 14.
Measurement of Anomaly within a Steel Part.

CIRCUIT ARRANGEMENT

Figure 11 is a block diagram of the major circuits; these can be switched to measure either the flux density or the gradient of a magnetic field.

The 3000-cycle oscillator is designed to supply a constant current to the current terminals of the probe elements. The potential leads are brought from the probes to their respective 3000-cycle filter, each having a 1000-cycle bandwidth. A balancing network is provided to inject small voltages into the pickup loop to balance out the residual resistive unbalance in each probe. The ZERO BAL. CONTROLS on the front panel adjust the phase and magnitude of these injected voltages. The purpose of each filter is to remove harmonic voltage from the signal as generated in the 3-kilocycle oscillator and with the adder circuit, step up the voltage. The signal is amplified and rectified to operate the meter or external recorder. The final stage uses current feedback to improve the linearity of the meter rectifiers and is powerful enough to drive many DC recorders directly without further amplification. The over-all sensitivity is varied with a front panel CALIBRATE control.

An 11-step attenuator permits full-scale measurements from 0.1 gauss to 20,000 + gausses. The adder circuit consists of two transistor amplifiers with a common collector load. This circuit adds the voltages from the "A" and "B" probes and provides a gain of about 10. A regulated power supply (either battery or AC) provides the necessary DC power voltage. Semiconductor devices are used for rectification and amplification in all circuits.

Each probe is driven by a constant current amplifier to insure linearity of the probe output with applied magnetic field. The Hall voltage outputs are adjusted exactly in phase by varying the tuning of the constant current amplifiers. The relative sensitivity of the probes is controlled by adjusting the gain of one of the current amplifiers.

The output voltage of each probe is balanced as closely as possible to zero in a 0-gauss chamber by inserting small voltages of the correct magnitude and phase in series with the Hall elements. These voltages are controlled by the A probe 4-way COARSE and FINE ZERO BAL. controls and the B probe COARSE, MEDIUM and FINE controls. The output voltages are then made equal with both probes held in a 100-gauss reference magnet field by adjusting the gain of one of the current amplifiers (control marked ZERO BALANCE DIFFERENTIAL); upon proper adjustment on the 1 gauss range, the meter will read within three divisions from zero with the Gaussmeter set up for DIFFERENTIAL operation. With the RANGE SELECTOR at LOW, MID or HIGH (depending on field strengths to be measured) and the GAUSSES FULL SCALE switch at 100, the amplifier gain is then adjusted until the meter reads full scale for either probe while both are in the reference field; either probe can then be used to measure the density, or both can be used to measure the gradient of a magnetic field. A 100-gauss reference magnet is necessary with the Model 1965, since this value is common to the LOW, MID and HIGH range groups.

For gradient measurements, the phase of one of the probes is reversed, and both are switched to the adder circuit. The difference in field intensity between the two probes is indicated by the meter and is shown graphically in Figure 13.

Normally, for measuring field gradients, the probes are fitted into the holder and held in parallel planes. Anomalies or flaws within a part can be detected as shown in Figure 14. Both probes are selected and matched for uniform response, which is within 1.5% over the entire useful range for gradient or difference measurements; the probe test data sheet gives specific values for all ranges. The degree of balance attainable between both probes while in a uniform field is better than 0.25%. Highest balance accuracies are realized when both probes are balanced in a uniform field whose value approximates the field to be measured.

Expanded scale mode of operation employs one probe as in normal, absolute field measurements. In expanded scale operation, an in-phase counter-emf is applied to the amplifier circuitry enabling the gaussmeter to be zero balanced while the A probe is in the presence of a field in the range of 1 to 15,000 gausses.

TEMPERATURE EFFECTS

The resistive zero balance of the probe is sensitive to temperature; the InAs element has a temperature coefficient of resistance about the same as copper. The zero shift is, of course, most apparent on the sensitive 0.1 gauss range. This shift is about one gauss for a 10°C change in element temperature. Each probe is individually checked for temperature/stability characteristics. Refer to probe calibration data for actual values.

The Hall coefficient of the InAs material also changes with ambient temperature. The sensitivity of the probe may change approximately 0.1%/°C when submitted to temperature variations after calibrating with a reference magnet. The reference magnets change approximately 0.02%/°C; the magnet will return to its original calibration when normal temperature is restored. An ambient temperature above 180°F may permanently change the calibration of the magnet. A variation in ambient temperature also changes the rectification efficiency of the diodes in the meter circuit. These changes are normally eliminated by calibration at the temperature of use.

Operation

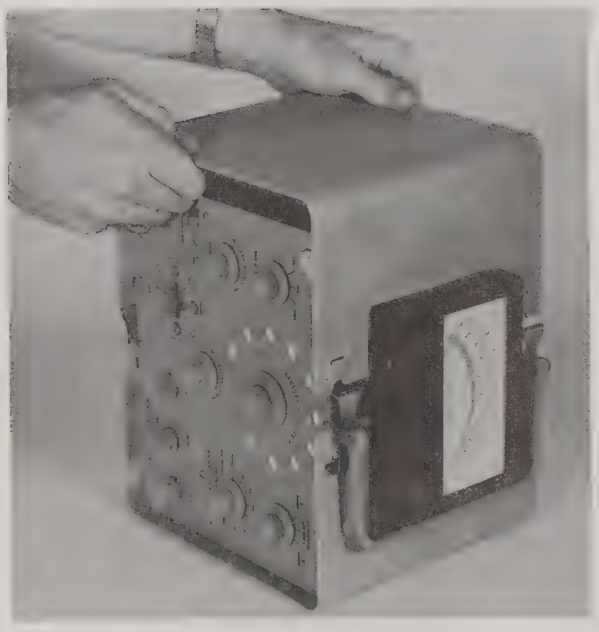


Figure 15.
Unlatch Four Catches and Slide Case Half Straight Up.

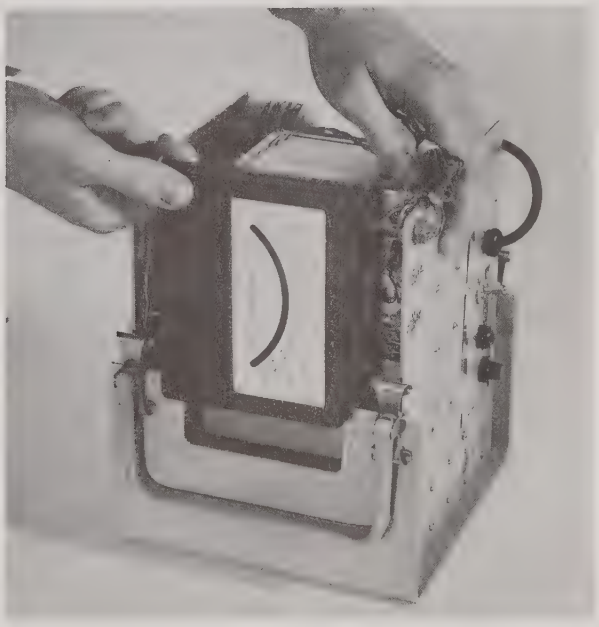


Figure 16.
To Remove, Slide Meter Straight Up.

UNPACKING THE EQUIPMENT

For shipment in the continental United States, the equipment is packed in commercial cardboard cartons. Upon receipt, the unit should be removed from the carton and inspected for possible physical damage in shipment.

The case of the Model 1965 is in two halves; they are identical and can be interchanged. Four double-ended butterfly type springs hold them to the front and rear panels. The meter and its easel mount are held on the top of the case by either or both of the case havles. To remove, place the gaussmeter flat on its right side and lift up the left case half, top and bottom evenly, as shown in Figure 15. The meter and its easel will remain in the right case half as shown.

Figure 16 shows the next step with the meter being withdrawn. The metal tray just below the meter holds the extra cable and protects the gaussmeter interior when the meter is used in remote location. Most important, it shields the amplifier transistors from the output meter leads when the meter is installed in the top of the gaussmeter. Be sure it is properly in place when returning the meter to its mounted position. Grommets are provided on the meter cable to fit the slots cut in the tray and the back

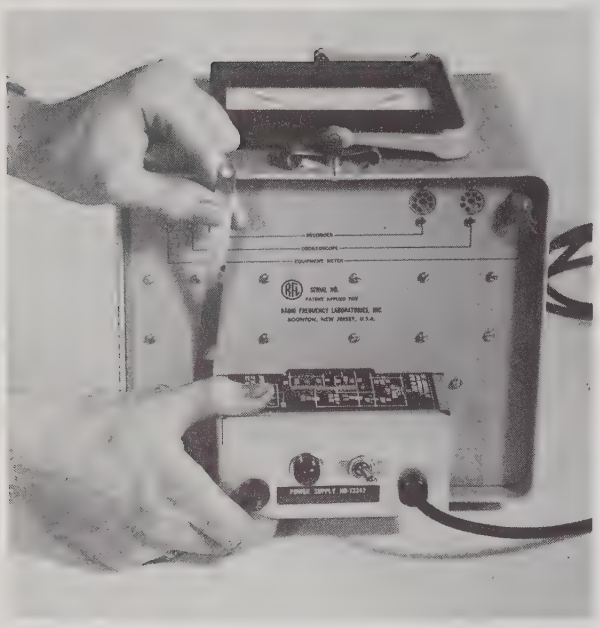


Figure 17.
Installing AC Power Supply.

panel; so that the cable may be extended and the case closed with the meter removed.

The power supply is normally installed in the gaussmeter before shipment. To remove, disengage the retaining spring by lifting center with fingernail and pulling right end off mounting screw head; then swing up to left as shown in Figure 17. Pull power supply directly back and out of equipment. When installing battery supply make sure terminal contacts are UP. Unless specified differently on the purchase order, the AC power supply is connected for 115-volt line operation. Always check the transformer connections before plugging into 230 volts; see schematic wiring diagram in back of this book.

Use cable and plug supplied (stored under meter) for connecting recorder or oscilloscope. Pin 7 is ground. Each receptacle is connected or disconnected by individual slide switches; use only one at a time.

Keep the probes in their plastic box until ready for use. It's always a good idea to leave them in the holder for additional protection, expecially when operating or checking out a Model 1965 for the first time.

CAUTION

InAs elements are brittle, are easily fractured if probe tip is bent, squeezed or flexed. Damaged probes will not be replaced under the equipment warranty.

If you do damage a probe, read Note on page 18 of the MAINTENANCE section.

Operational Procedure

ABSOLUTE MAGNETIC FIELD MEASUREMENTS

Only the A probe is used in absolute measurements. The B probe should not be plugged into its respective socket for this mode of operation.

A. Raise or remove meter from case, as desired. (Make sure it is plugged into the correct receptacle on back panel.)

B. Set RANGE SELECTOR to the LOW position, mode selector switch to A PROBE position and GAUSSES FULL SCALE to 100.

C. By means of A PROBE ZERO BAL CONTROL 4-way knob, adjust arrows in all four positions to point up. The lower COARSE position is a 3-turn helix, and the arrow should be up $1\frac{1}{2}$ turns from left or right, i.e. in the middle of the adjustment range.

D. Referring to the Probe Test Data Sheet under Approximate Calibration Control Setting, note the value given for the A probe and set the CALIBRATE control to this position. (The panel is not marked, but 0 is full counterclockwise and 10 is full clockwise; full rotation of the control is about 270°.)

E. Insert the probe into the ZERO GAUSS CHAMBER. Place the FUNCTION SELECTOR/EXPANDED SCALE ATTENUATOR switch to the NORMAL position.

F. Place the front panel equipment TRANSISTOR switch to the ON position. If the AC power supply is used instead of the battery power pack, it is also necessary to place the AC power pack switch to the ON position. Note: When operating from the battery power supply, the front panel equipment TRANSISTOR switch should be placed to the OFF position when the equipment is not in use to conserve batteries.

G. Move the A PROBE ZERO BAL CONTROL knob down into the COARSE position and carefully turn it for maximum leftward deflection (towards zero) of the meter pointer. With other hand rotate GAUSSES FULL SCALE step-by-step through lower ranges until no closer deflection to zero can be accomplished, then move know to upward COARSE position and repeat; then repeat with knob in left hand FINE position and finally in right hand FINE position with GAUSSES FULL SCALE on 1 gauss range. With everything in proper order, meter pointer should be within three scale divisions of zero on the 1 gauss range. (After practice, try this zero balancing operation on the 0.1 gauss range; it takes a light touch, and within 20 divisions of zero is pretty good. In actual use, it is necessary to zero balance on a lower range than the one which will give the required accuracy.

H. Turn the GAUSSES FULL SCALE switch back to the 100-gauss position.

I. Carefully insert the probe into the center of the 100-gauss Probe Reference Magnet. When performing this procedure, it is necessary to search along the plateau of the magnet gap for a maximum reading, and to keep the probe blade horizontal.

J. Adjust the CALIBRATE control located directly below the GAUSSES FULL SCALE switch for exactly Full Scale Deflection or 100-gauss Full Scale reading. The instrument is now set up for absolute magnetic field measurements.

INCREMENTAL VARIATION OF A FIELD

> REPEAT STEPS A THROUGH J IN THE " SETTING UP PROCEDURE FOR ABSOLUTE MAGNETIC FIELD MEASUREMENTS " SECTION.

A. Place the Probe into the Magnetic Field under study.

B. Turn the mode switch from the A PROBE position to the EXPANDED SCALE position.

C. Place the EXPANDED SCALE ATTENUATOR switch to the same value as the GAUSSES FULL SCALE switch (for values below 100 gausses set the ATTENUATOR switch to the 100 position and for values above 10 kilogauss set the ATTENUATOR switch to the 10K position.)

D. Adjust the EXPANDED SCALE ZERO BALANCE COARSE control for down-scale deflection (towards zero) of the Meter Pointer. With the other hand, rotate the GAUSSES FULL SCALE step-by-step through lower ranges until no closer deflection to zero can be accomplished. Then repeat adjustment with the MEDIUM control then repeat adjustment with the FINE control. It may become necessary to return to the MEDIUM control. NOTE THE NULL POINT VALUE.

E. Adjust the FINE EXPANDED SCALE control for a center scale reading of the Meter Pointer. To obtain maximum accuracy, turn the GAUSSES FULL SCALE switch to a range equal to 10 times the null value obtained in Step D. Now adjust the FINE EXPANDED SCALE control to the center scale meter position. The MEDIUM control should not be used. For example, if the null point value in Step D were 0.2 gauss on the 1-gauss range, then the typical operating range would be 2 gausses. With these settings, small variations can readily be observed.

DIFFERENTIAL OR GRADIENT FLUX MEASUREMENTS

The A probe and the B probe are both required in this measurement technique and they should be plugged into their respective sockets on the Gaussmeter rear panel.

A. Insert both probes in the holder supplied, illustrated in Figure 8, into the ZERO GAUSS CHAMBER.

B. Place the FUNCTION SELECTOR/EXPANDED SCALE ATTENUATOR to the DIFFERENTIAL position, and the Model switch, located directly above the FUNCTION SELECTOR/EXPANDED SCALE ATTENUATOR, to the A PROBE position.

C. Set the RANGE SELECTOR to the LOW position and the GAUSSES FULL SCALE to 100.

D. Repeat Step C under Absolute Field Measurements.

E. Repeat Step F under Absolute Field Measurements.

F. Repeat Step G under Absolute Field Measurements.

G. Turn the GAUSSE FULL SCALE back to the 100-gauss range and rotate the Mode switch knob from the A PROBE to the B PROBE position.

H. Repeat Step G under ABSOLUTE FIELD MEASUREMENTS using the three B PROBE ZERO BALANCE controls. These controls are indicated as COARSE, MEDIUM and FINE and they should be adjusted in this sequence. Note: If the meter deflects beyond full scale, place the GAUSSES FULL SCALE switch to a higher range until a normal meter deflection is obtained.

I. Turn the GAUSSES FULL SCALE switch back to the 100-gauss position.

J. Carefully insert the probes into the center of the 100-gauss PROBE REFERENCE MAGNET.

K. Place the Mode switch located above the FUNCTION SELECTOR/EXPANDED SCALE ATTENUATOR switch from the B PROBE to the DIFFERENTIAL/EXPANDED SCALE position and adjust the DIFFERENTIAL ZERO BALANCE control located below the RANGE SELECTOR switch for closest to zero deflection of the meter. (If the meter deflects off-scale to the right, probes are out of phase and one should be rotated 180°. Note the position of the serial numbers for future orientation. Repeat Zero Balance Procedure, Steps F and H with the probes in the ZERO GAUSS CHAMBER.

L. Repeat Step I above and Step I under ABSOLUTE MAGNETIC FIELD MEASUREMENTS.

M. Turn the Mode switch from DIFFERENTIAL/EXPANDED SCALE to the A PROBE position. Adjusting the CALIBRATE control, bring the meter pointer to full scale.

N. The ZERO BALANCE control should now be adjusted to bring the meter to full scale in the B PROBE position.

O. Place both probes in ZERO GAUSS CHAMBER and check zero balance for each probe. (See Steps F and H above.)

P. Return both probes to 100-gauss Reference Magnet and check full scale reading, readjust if necessary.

Q. Turn the Mode switch knob to the DIFFERENTIAL/EXPANDED SCALE position and with the ZERO BALANCE control, adjust the zero deflection the the meter while rotating the GAUSSES FULL SCALE SELECTOR down range. Minimum obtainable deflection will be about mid-scale on the 0.1-gauss range; the value recorded during calibration is shown on the Probe Test Data Sheet opposite A-B (Differential) for each set of probes. If minimum attainable delfection exceeds this value by 50% or more, an adjustment inside the Model 1965 must be made (See paragraph BALANCING EXTRA PROBE SETS on Page 16).

R. Probes are now balanced, calibrated and ready for use.

POLARITY OF MAGNETIC FIELDS BY CENTER SCALE POSITIONING OF THE METER POINTER

Only the A probe is used on this type of measurement, and the B probe should not be plugged into its respective socket.

A. Repeat Steps A - J under absolute measurements, and insert the probe into the ZERO GAUSS CHAMBER.

B. Place the Mode switch from the A PROBE to the DIFFERENTIAL EXP SCALE position, and the GAUSSES FULL SCALE switch to the desired range. For example, if we wish to observe a 100-gauss deviation either side of zero center on the meter scale, the 200-gauss range would be used.

C. Set the FUNCTION SELECTOR/EXPANDED SCALE ATTENUATOR switch to the corresponding GAUSSES FULL SCALE position in Step B above.

D. Adjust the expanded scale (B PROBE) ZERO BALANCE COARSE control, then FINE control for better resolution, to a center scale meter pointer indication.

The MEDIUM control should not be used for this operation.

E. Remove the probe from the ZERO GAUSS CHAMBER and carefully insert it into the center of the reference magnet. Care should be taken in the probe replacement as in Step I under ABSOLUTE MAGNETIC FIELD MEASUREMENTS. The meter deflection should be to

the left of zero center or towards zero on the upper three scale ranges. It may be necessary to turn the probe over 180 degrees for the required left of zero center deflection.

> **NOTE**
>
> In step "B" above, the 100-gauss reference magnet is required for full scale deflection of the meter.

F. Adjust the B PROBE ZERO BALANCE MEDIUM CONTROL for maximum leftward meter pointer deflection.

G. Remove the probe from the magnet and insert it in the ZERO GAUSS CHAMBER.

H. Repeat Step D.

I. Repeat Step E above, however, meter pointer deflection should be in the right of zero center deflection.

J. Adjust the CALIBRATION control setting fro all scale deflection.

K. Place the probe into the ZERO GAUSS CHAMBER and repeat Step D above.

L. Repeat Step I and then Step J above if necessary. The instrument is now set up for use.

OPERATIONAL CONSIDERATIONS

After the setting up procedure has been performed under DIFFERENTIAL or GRADIENT FLUX MEASUREMENTS, the A probe and the B probe may be used separately for single probe operation by placing the Mode switch from the DIFFERENTIAL/EXPANDED SCALE to the appropriate A or B probe position.

A zero center scale is provided for use in the expanded scale mode to allow changes of polarity to be determined while probing minute field variations. Larger changes of polarity can be observed using the Gaussmeter set-up under the operation procedure for POLARITY OF MAGNETIC FIELDS BY CENTER SCALE POSITIONING OF THE METER POINTER.

> **NOTE**
>
> Flat probes supplied with the Model 1965 Gaussmeter should be calibrated with 100-gauss ref. magnet unless otherwise noted on Data Sheet.

When operating in the expanded scale mode, the range selector switch must be kept in one position to avoid overdriving the summing amplifier. The amount of suppression depends on the range in use. For example, the typical suppression in a 10,000-gauss field is down to 6 gausses and down to .02 gauss in a 100-gauss field. Thus, resolution of variations as small as 1 milligauss may be seen in a 100-gauss field (this variation is on the order of 10 ppm) based on a variation of 1 scale division. Since resolution of the meter reading is much better than 1 division, it can readily be seen that variations of 5 ppm can be observed without undue difficulty.

Table 2 contains a chart listing typical suppression and resolution data. The maximum suppression is indicated by a down scale deflection or nulling action of the meter pointer during the setting up procedure under EXPANDED SCALE OPERATION.

Table 2.

TYPICAL SUPPRESSION & RESOLUTION DATA FOR EXPANDED SCALE OPERATION

Full-Scale Range (Gausses)	Maximum Suppression	Typical Operating Range
10,000	To 6 gausses on 10-gauss range (Resolution = 0.1 gauss/division.)	100 gausses full-scale Resolution = 1 gauss/division.
1000	To 0.2 gauss on 1-gauss range (Resolution = 0.01 gauss/division.)	2 gausses full-scale Resolution = 0.02 gauss/division.
100	To .02 gauss on 0.2-gauss range (Resolution = 0.002 gauss/division.)	0.5 gauss full-scale Resolution = 0.005 gauss/division.
10	To .02 gauss on 0.1-gauss range (Resolution = 0.001 gauss/division.)	0.5 gauss full-scale Resolution = 0.005 gauss/division.

NOTE: Ranges from 1 to 10,000 gausses full scale (and to 15,000 gausses on 20,000-gauss full-scale range) can be used in expanded scale mode of operation. The above data show typical suppression characteristics. Ranges below 1 gauss full-scale may be used in expanded scale operation; however, the residual amplifier noise (approximately 0.02 gauss) limits the usefulness of the lower ranges.

On the ranges below one gauss, temperature becomes an increasingly important factor. Temperature change effect is given in the probe Test Data Sheet. Also, any mechanical strain applied to the element is readily indicated. Both conditions can be observed by breathing on the probe and lightly touching its end after zero balancing. Moving the cable excessively, especially where it enters the plug body, can cause erratic readings on the 0.1 gauss range, hence taping it to the case or rest an anchor weight on it is recommended during the zero balancing procedure.

Magnetic measurements can be made intermittently or continuously over periods of several days; provided the ambient temperature remains reasonably constant ($\pm 2^{\circ}$) and the line voltage stays between 100 and 130 volts, the stability of the system is such that readings will not deviate more than 1% from optimum.

USE OF PROBE TEST DATA

Unfortunately, the Hall effect of InAs is not linear when subjected to fields from near zero to more than 20K gausses. With careful measurement and loading, elements can be selected to provide all points on their response curves within three meter divisions from 0.1 to 10,000 gausses when calibrated in a single reference magnet. Above 10K gausses the response falls off fairly rapidly, and calibration data or correction factors are necessary. Using the reference magnet supplied, direct reading accuracy on all full-scale ranges from 0.1 to 10K gausses will be within ±3%. For accuracy approaching ±1%, the meter reading may be corrected with the calibration data furnished.

Where different types of probes are used, check the Test Data Sheet for each to determine the value of reference magnet for calibration. Also check the position of the filter and oscillator taps to make sure the pin of plugs within the gaussmeter match the positions given on the Test Data Sheet for that probe. All dual flat probe sets for the Model 1965 use the same filter and oscillator taps; however, a different internal balance adjustment may be necessary, as explained below.

BALANCING EXTRA PROBE SETS

When replacement, dual probe sets are to be used on a Model 1965 already in service or extra probe sets are ordered for the Model 1965, an internal balance adjustment may have to be made to permit balancing both probes (of extra set) in the differential mode position.

This condition can be determined at step Q under the setting up procedure DIFFERENTIAL OR GRADIENT FLUX MEASUREMENTS. (Be sure to complete all preceding steps.) With all steps up to and including Q completed, the minimum attainable deflection should be about mid-scale on the 0.1-gauss range; the value recorded during calibration is listed on the Probe Test Data Sheet opposite A-B (Differential) for each set of probes. If minimum attainable deflection exceeds this value by 50% or more, remove the right side of the equipment case, exposing the A PROBE oscillator. On top of this oscillator is a trimmer capacitor marked C38. Repeat the DIFFERENTIAL ZERO BALANCE control adjustment in step Q, then adjust C38 for minimum meter pointer deflection. It may be necessary to repeat these two adjustments several times to achieve the value nearest to zero on the 0.1-gauss range. The Model 1965 will then be adjusted for optimum differential balance for the particular set of probes.

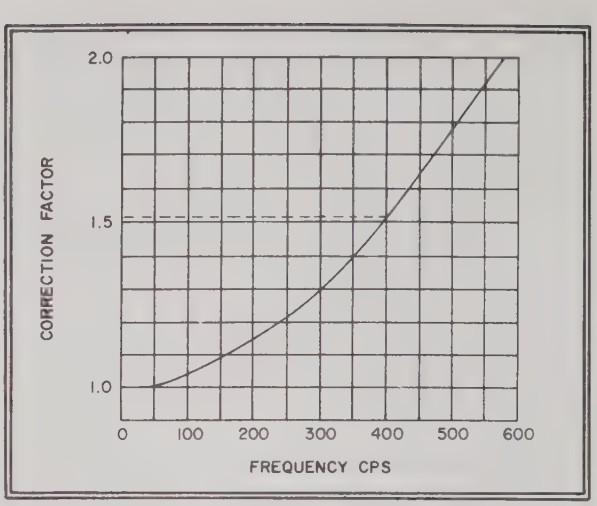


Figure 18.
Frequency Response of Model 1965 Gaussmeter.

MOST ACCURATE MEASUREMENT OF FIELDS FROM 10K TO 30K GAUSSES

By measurement and loading of selected InAs elements it is possible to provide single flat probes and calibration curves for accurate (within ±1%) field measurements to 30K gausses. Two choices are presently available: Option "A" and Option "B".

Option "A" - Where single flat probe magnetic field measurements are to be made from 10K to 20K gausses and maximum accuracy is desired, a selected probe and calibration curve plotted from 5K to approximately 25K gausses can be purchased. The curve is in addition to the Probe Test Data Sheet normally supplied. A 100-gauss reference magnet is also required. Accuracy of measurement will be within ±3% from 1 to 20K gausses overall and within ±1% to ±2% on many of the ranges.

Option "B" - Where single probe field measurements in the range of 20K to 30K gausses are desired a selected probe and calibration curve plotted from 5K to 27K gausses can be supplied. A 10K-gauss reference magnet is required and, using the data from the curve, measurements can be made to an accuracy of ±1% from 5K to 30K gausses. This probe is not calibrated below 5K gausses and, due to its nonlinear characteristics at lower ranges, should not be used for low level work.

AC FIELDS

When the probe is placed in an AC magnetic field the meter reads the average value of the field. For sine wave

fields above 50 cps, multiply the meter reading by the correction factor given in Figure 18. If the wave shape of the field is of interest, a rear panel oscilloscope switch is provided to switch the rectifier and meter out of the circuit and substitute a 2.2K resistor R75 for an output load. The oscilloscope output is taken across this resistor and displays the carrier and its envelope. The peak signal can be set at 2 volts for full scale. The output may be termed as double sideband with suppressed carrier.

It should be noted that the expanded scale feature is applicable only to fixed magnetic fields. Fields having a repetitive rate of change, such as an AC field, cannot be measured in the expanded scale mode.

Maintenance

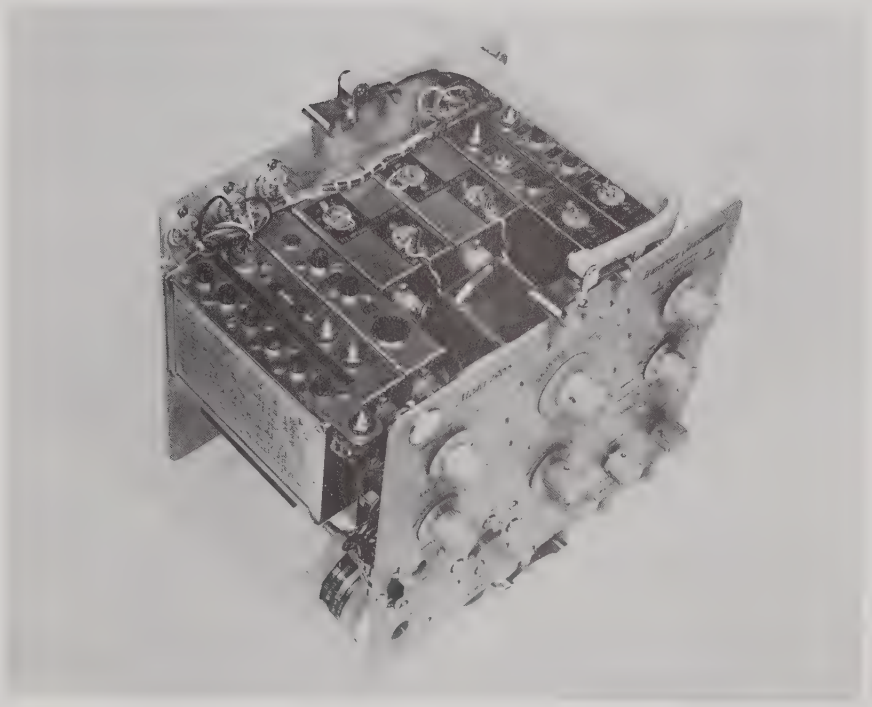


Figure 19. Inside View Showing Major Assemblies.

NOTE

Be certain the DIFFERENTIAL ZERO BALANCE control on the front panel is set near the mid-point of its range for both "A" and "B" probe oscillator adjustments.

CALIBRATION PROCEDURE

Oscillator HB-21835 - As shown in the schematic diagram (foldout at end of book) and in Figure 20, the oscillator coil L2 has a multi-tap secondary for matching into the current terminals of the Hall element. The position of the pin in SP7 and the matching impedance are given in the test data for each probe. The adjustment of the oscillator consists of setting the OSC. GAIN control R8 on the oscillator unit for an output or drive voltage of 0.1 volt after inserting a 2-ohm, ±1% resistor between pins 1 and 3 of the B PROBE receptacle on the rear panel of the gaussmeter. The pin in SP7 must be in the 5-ohm tap for this adjustment.

Oscillator Amplifier HB-21840 - Adjustment of this oscillator is similar to Oscillator HB-21835. Connect a 2-ohm ±1% resistor between pins 1 and 3 of the A PROBE receptacle (back panel of gaussmeter) and adjust R92 to 0.1 volt. The pin in SP7 of Oscillator HB-21835 must be in the 5-ohm tap.

A trimmer capacitor C38 in the collector tank circuit is mounted in the top of the case to adjust the phase of the "A" probe output voltage to be exactly in phase with the "B" probe output. The capacitor C38 is adjusted in its initial alignment with the DIFFERENTIAL control set to the A MINUS B position.

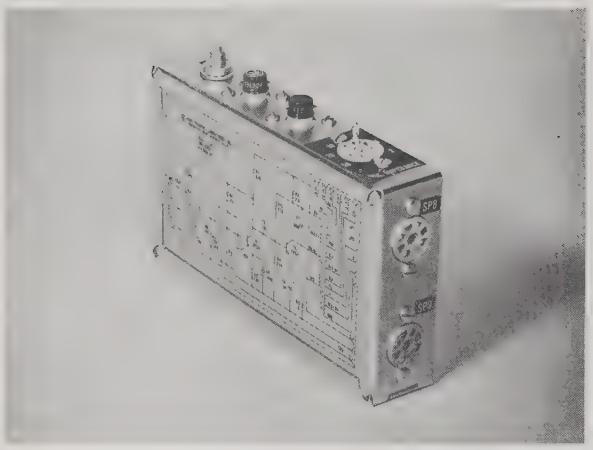


Figure 20.
Oscillator, HB-21835.

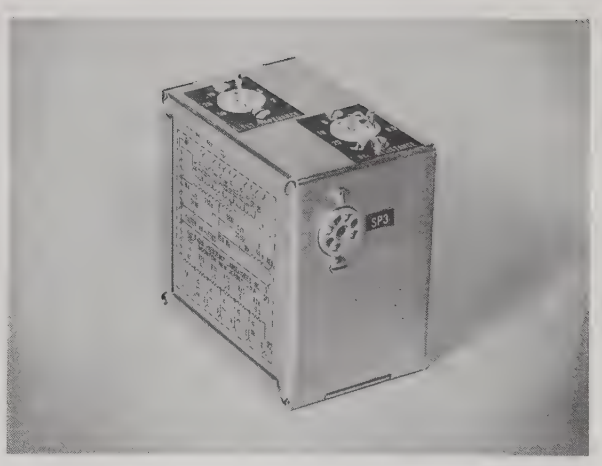


Figure 21.
Filter, HB-13310

Differential Amplifier HB-13344 - This amplifier is checked by applying signal to first one input and then the other at pins 3 and 5 of socket SP17 while measuring the output at pin 7 of socket SP17. The gains of each channel should be equal with pins 4 and 6 grounded or with pins 4 and 6 open. The output at pin 7 should be held under one volt. Signal can be applied to the inputs by subjecting the probes one at a time to a 1000-gauss field.

Hall Probe Elements - The nominal resistance of InAs probes is 2 ohms between the current leads and 1 ohm between the Hall contacts. The 3000 cps current through the current contacts is, therefore, approximately .050 ampere.

Load resistors, when required for best linearity to strong fields, are determined for each Hall probe and mounted in the connector plug. (See schematic diagram). The procedure for determining the load resistor for the "A" probe Hall element is to connect a variable resistance box across pins 3 and 4 of socket SP10 (see schematic diagram) and adjust the resistance of the box so that full-scale readings on the 1000, 2000, 5000 and 10,000-gauss ranges are within 3% of the full-scale mark. This requires probe reference magnets at the above values. With the probe unloaded, the readings at 5000 and 10,000 gausses will be low by about 4% to 8% when the instrument has been initially set at 1000 gausses. As the shunting resistor is changed, the CALIBRATE control must be reset at 1000 gausses.

A resistive value is selected that places the 5000-gauss range 1% to 2% high and the 10,000-gauss range about 2% low. The value so obtained is Ra and is soldered across pins 5 and 7 of the probe plug. A resistor in position Rb may be used to further improve linearity. For most RFL InAs probes this Ra loading resistor varies between 2 ohms and 15 ohms when the probe is driven from the 5-ohm tap on the oscillator output transformer and the input impedance tap to the filter is set at 5 ohms. The internal driving impedance of the oscillator affects the linearity of the elements and in general should be kept high by using the 5 or 10-ohm output tap with the loading being accomplished with the resistor across the Hall contacts.

Calibration records on each range are provided for the probes and gaussmeter supplied on each order. These data permit measurement to a greater accuracy than the direct reading accuracy. Probes can be interchanged between units without loss of the direct reading accuracy. For highest accuracy, the probes should be calibrated on the instrument with which they are used.

The sensitivity of a probe may be checked by measuring the AC voltage present at the output of the filter between pin 1 and 5 of P3 for the "B" probe with 1000 gausses applied to the probe. The same applies to the "A" probe when measured between pin 1 and 5 of P18. The drive voltage for both "A" and "B" probes should be set carefully as outlined under calibration procedure (page 17). The sensitivity or signal output of the filter should be between .05 and .09 volt for 1000 gausses.

NOTE

If either probe has been damaged it may still be usable for flux density measurements on the higher ranges. If partial fracture of the element has occurred, the probe cannot be zero balanced to any useful accuracy on the low ranges but, by checking its zero balance on higher ranges, it can be determined if it will yield useful readings at these higher gauss levels. The scale reading above zero to which it can be balanced on a given range will indicate the accuracy of reading on that range.

A damaged probe cannot be used for differential measurements; both probes should be returned to RFL for proper matching and calibration when replacement of the damaged probe is desired.

Amplifier HB-20995 - The adjustment of the amplifier unit shown in Figure 22 consists of setting the input resistance of the amplifier to 2500 ohms and the setting of three gain controls. The input resistance of the amplifier is varied with the ADJ control R48. Place a high impedance vacuum tube voltmeter between pin 7 of the differential amplifier plug P17 and ground (pin 1 or 2 of P17).

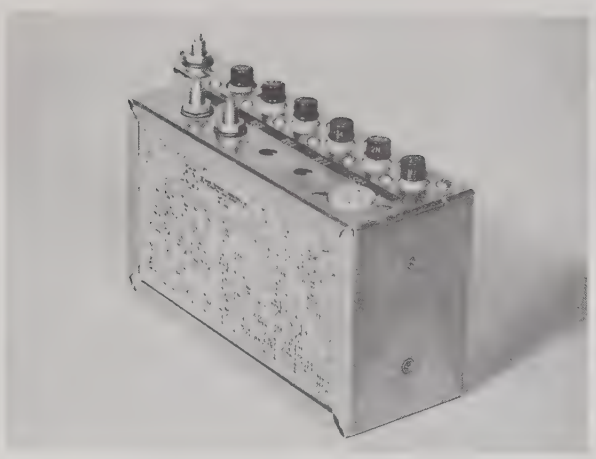


Figure 22.
Amplifier, HB-20995.

With both probes plugged in and the RANGE SELECTOR set to HIGH position and the GAUSSES FULL SCALE switch set to the 10-gauss position, adjust the A PROBE ZERO BAL control in its lower COARSE position until the voltmeter reads .004 volt. Then move the ungrounded voltmeter lead to pin 5 of plug P4 on the amplifier subassembly and adjust R48 until the voltmeter reads .002; repeat operation until the voltage at pin 5 of plug P4 is 1/2 the voltage at the differential amplifier output. Since the multiplier resistor is 2500 ohms ±1%, the test operation sets the input to the amplifier to 2500 ohms as required to obtain the correct attenuation on the other gauss ranges.

The over-all sensitivity of the amplifier is adjusted by means of the potentiometers R64, R74 and the CALIBRATE control R76. The maximum sensitivity (CALIBRATE control in maximum clockwise position) is set by varying R74 and R64 (on top of the amplifier) until .00375 volt on pin P18 of the "A" channel filter brings the meter to full scale on the 100-gauss range with S6 set to HIGH. The input voltage is set up with the lower COARSE A PROBE zero setting control. The potentiometers R74 and R64 are first set in the center and both shifted, as required, to maintain approximately the same gain in each transistor amplifier pair.

NOTE

Shifting RANGE SELECTOR switch S6 after calibrating with the reference magnet and CALIBRATE control may cause an error.

To calibrate the LOW, MID and HIGH range the following procedure must be observed. Place the RANGE SELECTOR S6 in the LOW position. Be sure unit has been zero balanced (page 13. paragraph B-H under Absolute Magnetic Field Measurements). Place probe in 100-gauss reference magnet adjust CALIBRATE CONTROL R76 for 100-gauss full scale. Place RANGE SELECTOR to MID range adjust potentiometer R58 on the top of amplifier subassembly for 100-gauss full scale. Place RANGE SELECTOR to HIGH range adjust R81 on the amplifier subassembly for the 100-gauss full scale. Both R58 and R81 will not change the original setting of the CALIBRATE CONTROL R76.

To calibrate the attenuator, a complete set of reference magnets for the full-scale reading on each range is required. The attenuator resistance values are set so that, after calibration is performed with one reference magnet, the other full-scale values will fall within ±2%. For maintenance purposes a partial check on the attenuator and probes would be to set the CALIBRATE control for full scale on the 100-gauss MID range with the 100-gauss reference magnet, then measure this field on the 200 and 500-gauss ranges. No adjustment is provided in the attenuator, and a failure in the attenuator will normally require that the equipment be returned to the factory for repair. One probe can be used to check the other.

TROUBLESHOOTING

If trouble develops in the Model 1965, follow the Troubleshooting Chart of Table 5 and make the measurements shown in Tables 3 and 4 to locate the trouble.

The modular form of the oscillator, the filter, and the amplifier makes their replacement easier than repair within the equipment. The gaussmeter is more quickly put back in service. For those who have more than one gaussmeter (either RFL Models 1890 or 1965) extra units may well be kept for immediate service while the faulty module is returned to RFL for repair.

The Table of Electrical Parts is for your convenience in ordering replacements when necessary.

Table 3.
AC Voltage Chart

AC LINE SUPPLY

NOTE
All measurements made with a high impedance vacuum tube voltmeter.

POINTS OF TEST	AC VOLTAGE
OSCILLATOR	
P9-3 to GND	0.1
TR1 - B to GND	.098
TR1 - C to GND	3.55
TR2 - B to GND	.075
TR2 - C to GND	4.5
SP10 - 2 to SP10 - 1	.17*
P8 - 3 to P8 - 5	.12
OSCILLATOR AMPLIFIER	
P15 - 3 to GND	.89
TR11 - B to GND	.076
TR11 - C to GND	4.5
SP14 - 3 to SP14- 5	.12
AMPLIFIER - 1000-gauss MID range.	**1000-gauss field thru "A" probe.**
P18 - 1 to GND	.062*
P4 - 5 to P4 - 1	45 uv ±10% CALIBRATE control at max. CL 110 uv ±10% CALIBRATE control at max. CCL
TR3 - C to GND	.0018
TR4 - C to GND	.043
TR5 - C to GND	.0015
TR6 - C to GND	.067
TR7 - C to GND	.0195
TR8 - C to GND	2.4
P5 - 2 to GND	2.3
DIFFERENTIAL AMPLIFIER - Same conditions as AMPLIFIER.	
TR9 - B to GND	.062
TR9 - C to GND	.765
TR10 -B to GND	
TR10 C to GND	.77

* Will vary with different probes

Table 4.
DC Voltage Chart

AC LINE SUPPLY

POINTS OF TEST	DC VOLTAGE
POWER SUPPLY - 115 V AC	
Power Supply Contacts	10 ±10%
BATTERY SUPPLY - 18 V DC	
OSCILLATOR	
P9 - 5 to GND	18.8
TR1 - C to GND	7.8
TR1 - B to GND	1.3
TR1 - E to GND	1.35
TR2 - C to GND	16.3
TR2 - B to GND	6.55
TR2 - E to GND	6.5
OSCILLATOR AMPLIFIER	
P15 - 5 to GND	18.8
TR11 - B to GND	6.2
TR11 C to GND	16.5
TR11 - E to GND	6.2
AMPLIFIER	
P6 - 7 to GND	18.8
TR3 - C to GND	3.9
TR3 - B to GND	.73
TR3 - E to GND	.73
TR4 - C to GND	10.
TR4 - B to GND	3.9
TR4 - E to GND	4.2
TR5 - C to GND	4.6
TR5 - B to GND	.1
TR5 - E to GND	.002
TR6 - C to GND	9.1
TR6 - B to GND	4.6
TR6 - E to GND	4.65
TR7 - C to GND	5.5
TR7 - B to GND	.155
TR7 - E to GND	.1
TR8 - C to GND	17.7
TR8 - B to GND	5.6
TR8 - E to GND	5.8
DIFFERENTIAL AMPLIFIER	
P16 - 5 to GND	18.8
TR9 - E to GND	17.
TR9 - B to GND	2.17
TR9 - C to GND	2.21
TR10 - E to GND	2.23
TR10 - B to GND	2.17
TR10 - C to GND	17.

Table 5.
Trouble Shooting Chart

SYMPTOM	CAUSE	REMEDY
No pilot lamp on AC Supply.	Blown fuse, faulty plug P14.	Check for shorts in the power supply and replace fuse. Measure DC output of power supply to be 18 volts ±10%.
ZERO BAL CONTROLS have little or no effect on the 10-gauss range.	Amplifier not functioning. Open potential leads in probe element or open cable.	Check "B" probe by shorting pins 3 and 4 of SP10 together and operate its ZERO BAL CONTROL. (Check "A" probe by shorting pins 8 and 9) If meter does not respond, troubleshoot the amplifier. If meter can be zeroed, probe element leads or cable are faulty.
	Oscillator not functioning.	With "B" probe removed, check AC voltage between pins 1 and 2 of connector SP10. If no voltage, troubleshoot the oscillator circuit and power supply. Check between pins 6 and 7 of SP10 for "A" probe.
	Open current leads in probe element or open cable.	Measure with ohmmeter and replace probe or repair cable.
OSCILLATOR No oscillator output voltage.	Defective component in oscillator subassembly. Defective DC power supply circuit.	Troubleshoot oscillator circuit using Tables 3 and 4 for guides as to voltages. Troubleshoot power supply circuit.
AMPLIFIER Measure voltage of approximately .025 volt on pin 1 of P3 for 1000 gausses on "B" probe.	Defective filter.	Remove filter connections and test with 50 ohms input impedance and 5000 ohms on output. The step-up ratio is approximately 10. Bandwidth about 1000 cycles. Center frequency of 3000 cycles. Replace filter if defective.
No amplifier output indicated by meter.	Defective component in amplifier or meter circuit.	Signal trace circuit by applying 3000-cycle signal to input terminals P4-5 and P4-1 and use Tables 3 and 4 as voltage guides.

Table of Electrical Parts

*Recommended Spare Parts for Overseas Use

RFL PART NO.	QUAN.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
*HA-14265	12	BATTERY, dry cell: 1½ v, size D.	
H-1007-207	2	CAPACITOR, electrolytic: 25 mf, 50 v.	C9 & C10
HA-13163	9	CAPACITOR, electrolytic: 25 mf +100% -10, 25 v.	C11 to C15, C19, C34, C41, C42
HA-13167	5	CAPACITOR, electrolytic: 10 mf +100% -10%, 25 v.	C4, C6, C21, C24, C26
HA-10271	2	DIODE, silicon: F2.	CR1, CR2
HA-13918	1	DIODE, silicon: 10M19Z.	CR3
HA-13242	4	DIODE: 1N155	CR4, CR5 CR6, CR7
*HA-9348	1	FUSE: 1/2 amp, 3 AG.	F1
HA-1816	1	FUSEHOLDER	XF1
HA-2468	1	LAMP, glow.	I2
HA-11645	1	MAGNET, Reference: 100-Gauss.	
HB-16097	1	METER, Milliammeter DC (Gauss).	M1
HA-13260	13	PLUG, tube base.	P3, 4, 5, 6, 8, 9, 11, 12, 14, 15, 16, 17, 18
HB-17120	1	PROBE, Flat Dual, Differential (calibrated together).	
HB-15950	AF	PROBE, Single (½ of Diff. Probe).	
HB-11240	1	REFERENCE CHAMBER, Zero Gauss.	
HA-9267	4	SWITCH, slide: DPDT.	S1, 2, 3, 7
HC-9372	1	SWITCH, toggle: DPST Bat handle	S5
HA-9356	1	TRANSFORMER, power.	T1
*HA-3166	2	TRANSISTOR, PNP, type 2N321.	TR2, TR11
*HA-9365	9	TRANSISTOR, type 2N324.	TR1, 3, 4, 5 6, 7, 8, 9, 10

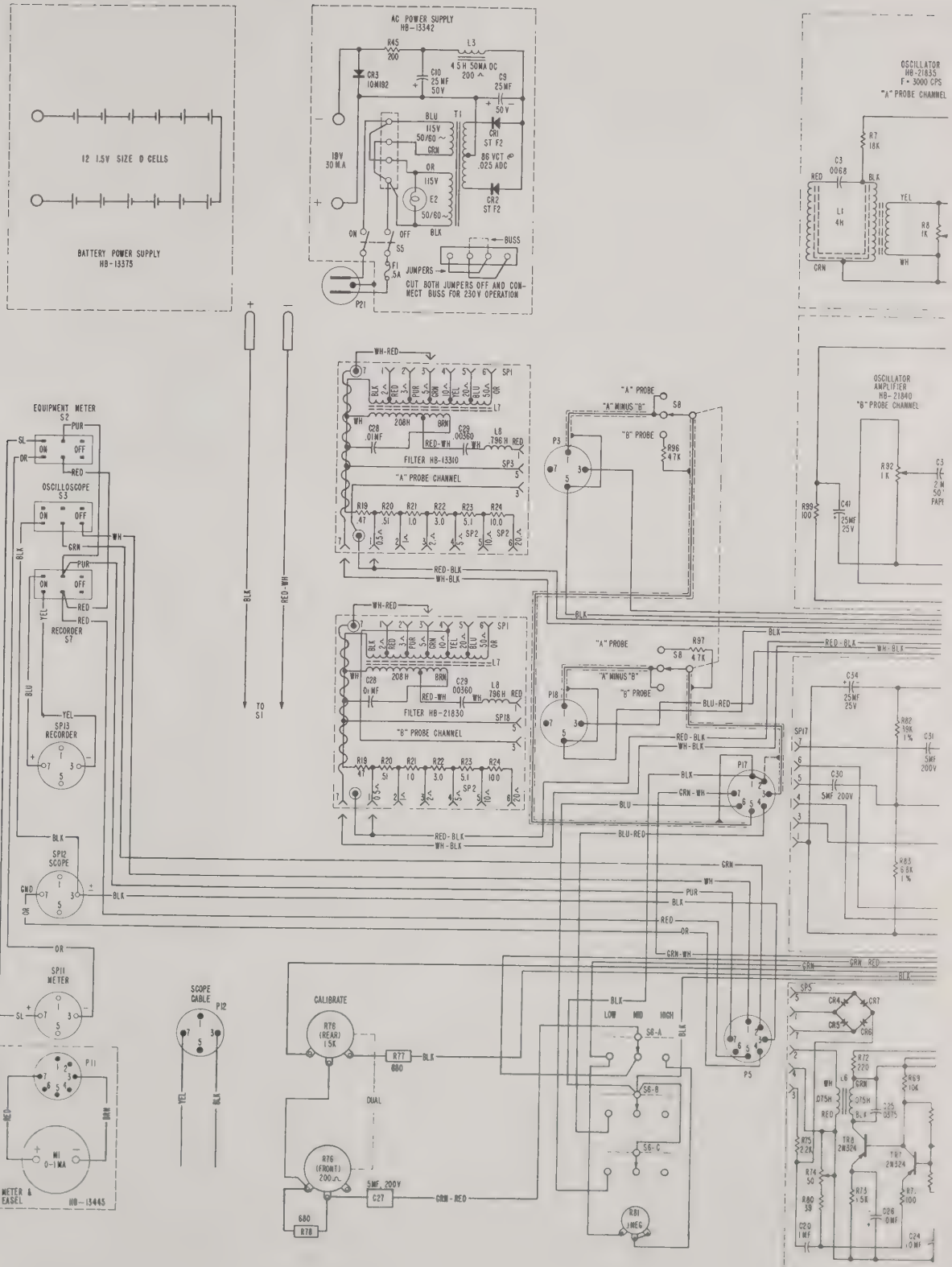
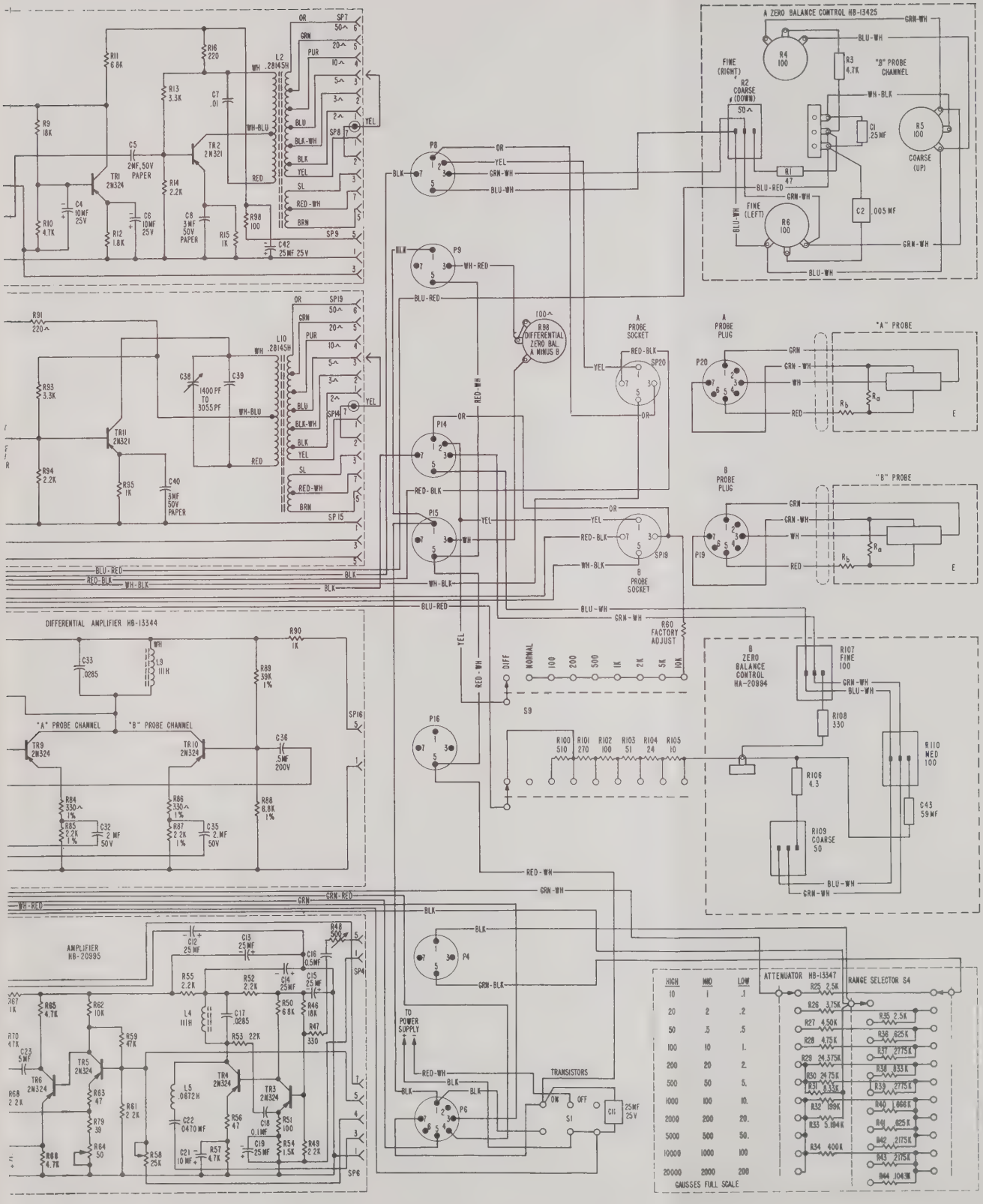
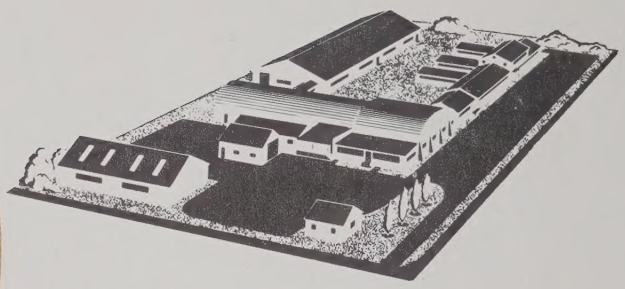


Figure 23. Schematic Diagram of Model 1965 Universal Gaussmeter.


A ZERO BALANCE CONTROL HB-13425
FINE (RIGHT)
COARSE (DOWN)
"B" PROBE CHANNEL
COARSE (UP)
FINE (LEFT)
DIFFERENTIAL AMPLIFIER HB-13344
"A" PROBE CHANNEL
"B" PROBE CHANNEL
AMPLIFIER HB-20995
A PROBE SOCKET
B PROBE SOCKET
A PROBE PLUG
B PROBE PLUG
"A" PROBE
"B" PROBE
DIFFERENTIAL ZERO BAL. A MINUS B
A ZERO BALANCE CONTROL HA-20984
B ZERO BALANCE CONTROL HA-20984
FACTORY ADJUST
TO POWER SUPPLY
TRANSISTORS
ATTENUATOR HB-13347
RANGE SELECTOR S4
GAUSSES FULL SCALE



Warranty

The Model 1965 Universal Gaussmeter carries a warranty of 12 months from date of delivery for replacement of any part, except probes, which fails during normal operation or service. A deficient part should be returned to the factory, shipping charges prepaid, for replacement f. o. b. Boonton, N. J.

Radio Frequency Laboratories, Inc.
BOONTON, NEW JERSEY, U.S.A.

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